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Fusarium infections of small cardamom in the field and its management

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Small cardamom (*Elettaria cardamomum* Maton) is one of the most valuable spice crops of India. The production of small cardamom is limited due to a number of fungal diseases. Root tip rot and foliar yellowing of small cardamom caused by *Fusarium oxysporum* Schlecht has been reported as a major problem in cardamom growing areas in Idukki district of Kerala (Thomas *et al*., 2006). Another disease observed is dieback or wilting of panicles during post monsoon period caused by *Fusarium oxysporum* (Thomas and Vijayan, 2002). *Fusarium* infections in cardamom have been reported earlier as capsule infection (Wilson *et al*., 1979), seed rot and seedling wilt in nurseries (Siddaramaiah *et al*., 1988) and stem rot (Dhanapal and Thomas, 1988). In addition to the incidence and spread of number of fungal and viral diseases, the cultivation of small cardamom and maintenance of healthy plants have become difficult due to the incidence and spread of *Fusarium* infections in recent years (Vijayan *et al*., 2008). Of late, capsule rot, root tip rot, leaf yellowing, pseudostem rot, panicle wilt and rhizome rot are commonly encountered in the cardamom growing tract. Therefore, the present study was undertaken to survey the incidence of *Fusarium* diseases in the field, isolation and confirmation of the pathogen involved and to develop a suitable and effective management strategy using bio-agents under field conditions.

Survey for incidence of *Fusarium* diseases

Incidence of root tip rot and foliar yellowing, pseudostem rot, panicle wilt and rhizome rot was recorded during the survey conducted in small cardamom plantations in Idukki district during 2009-11. Randomly selected plantation in different locations was assessed for various *Fusarium* disease incidences based on characteristic symptoms of root tip rot, foliar yellowing, pseudostem (tillers) rot, panicle wilt and rhizome rot. Healthy and diseased plants (clumps) were counted in each disease prone plot. Percentage of infection was calculated from 100 plants observed at each location and infected plants were collected from different locations for isolation of the pathogen.

Isolation of pathogen, identification and pathogenicity studies

The pathogens were isolated and purified by adopting standard procedures and their pathogenicity was tested under laboratory and green house conditions. Cultural and morphological characteristics were studied by growing the pathogens on potato dextrose agar. The pathogens were identified based on their morphology and spore characteristics. The isolates of the pathogens were tested by inoculating the healthy plants/ plant parts such as root, pseudostem, panicle and rhizome using macerated 10 days old fungal cultures as well as using spore suspensions in distilled water (10^7 cfu mL^{-1}). Pathogenicity studies were also carried out with the crude extracts of metabolites (toxins) of the pathogen in seedlings maintained in the green house. The inoculated plants were well maintained and observations on development of

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disease symptoms were recorded. Re-isolations of pathogenic fungi were carried out from inoculated seedlings/plant parts after the development of visible symptoms. Pathogens isolated from diseased plant parts were also cross inoculated on roots, panicles, rhizomes and pseudostem of cardamom for comparative studies. Inoculations were made on detached healthy plant parts such as roots, pseudostems, panicles and rhizomes thoroughly washed in distilled water and kept under humidity maintained chambers for 48 hours. Inoculations were also made using sporulated discs of the fungus and making pin pricks on healthy plant parts.

Disease management studies in the field

The experiment was conducted in *Fusarium* disease prone six year old cardamom plantation in the field at Pothakally (Idukki district) during the post monsoon period of 2009-11. The trial was laid out in randomized block design and each treatment was replicated four times with 12 plants per plot. The plots were maintained following standard agronomic practices. The treatments were: T1) *Trichoderma harzianum* (10^9 cfu mL^{-1}) as basal application + *Pseudomonas fluorescence* (10^9 cfu mL^{-1}) as foliar spray and soil drenching, T2) T1 + basal application of entomo-pathogenic nematode (EPN), T3) T1 + basal application of *Paecilomyces* (10^7 cfu mL^{-1}), T4) T2 + basal application of *Paecilomyces* (10^7 cfu mL^{-1}), T5) Effective microorganism (EEM) as foliar spray and basal drenching (10^9 cfu mL^{-1}). T6) Carbendazim 50 per cent WP + Mancozeb 75 per cent WP @ 0.3 per cent. T7) basal application of EPN, T8) basal application of *Paecilomyces* (10^7 cfu mL^{-1}), T9) control. Three rounds of applications of bio-agents and fungicides were given at monthly intervals starting from the month of January. All the plants in the trial plots were given vermicompost @ 5 kg $plant^{-1}$. In all the cases spray and soil drenching with respective treatments were given after phytosanitation. Per cent disease incidence was calculated by counting the total number of plants in each plot and number of plants showing disease symptoms. Population levels as colony forming units (cfu) of bio-agents and pathogen were also recorded after 30 days of imposition of treatments. The data were statistically analyzed.

Survey for incidence of *Fusarium* diseases affecting small cardamom

Disease survey was carried out in 93 plantations covering 13 villages during 2009-10 and 47 cardamom growing locations covering 66 plantations during 2010-11. *Fusarium* root rot and foliar yellowing incidence varied from 0 to 48 per cent during 2009-10 (Table 1) and it increased up to 68 per cent during 2010-11 periods (Table 2).

Table 1. Percentage disease incidence of *F. oxysporum* in different cardamom growing locations during 2009-10

Sl. No.	Village/location	No. of plantations surveyed	Root rot	Pseudo stem rot	Rhizome rot	Panicle wilt
1	Anakkara	6	1	2	1	1
2	Ayyapankovil	1	1	4	2	0
3	Chakkupallam	13	2	2	6	1
4	Elappara	14	1	2	1	1
5	Karunapuram	3	1	1	1	1
6	Kattapana	3	2	2	4	1
7	Kumily	3	4	2	5	0
8	Manjimala	6	0	0	0	0
9	Peerumedu	2	0	0	0	0
10	Periyar	6	3	4	3	0
11	Santhanpara	14	1	0	0	0
12	Vagamon	4	2	4	3	1
13	Vandenmedu	11	1	8	2	5
14	Kajanappara	1	0	1	0	0
15	Puthukai	4	1	6	3	0
16	Pothakkally	2	48	14	4	14

Table 2. Survey on the incidence of *F. oxysporum* infections in small cardamom for different locations of Idukki district during 2010-11

Sl.No	Locations	No. of plantations surveyed	Pseudo stem rot	Rhizome rot	Panicle wilt	Root tip rot
1	Balagram	1	-	25	-	-
2	Chathurangapara	1	-	-	2	-
3	Chemmannar	2	-	-	-	68
4	Chakkupallam	1	-	11	-	-
5	Chettukuzhy	1	20	-	-	-
6	Combayar	1	-	25	-	60
7	Elappara	4	30	36		
8	Eattythoppu	1	-	-	-	30
9	Kallupalam	1	-	30	80	-
10	Kattapana	1	-	50	-	-
11	Kadamakuzhy	2	14	-	-	-
12	Kalkoonthal	1	-	15	-	-
13	Kalvarymount	2	-	30	25	-
14	Kochara	1	15	-	-	-
15	Kambamettu	1	5	-	-	-
16	Karithode	1	-	-	-	50
17	Kumily	2	-	8	-	-
18	Kanjikuzhy	2	15	25	-	-
19	Kuzhitholu	2	55	-	-	55
20	Karunapuram	2	-	-	-	14
21	Melachinnar	1	20	-	-	10
22	Marygiri	1	-	-	-	15
23	Mattukkatta	1	-	-	-	45
24	Mavady	1	30	-	-	-
25	Muniyara	1	-	-	-	6
26	Myladumpara	1	-	1	-	-
27	Munnar	1	22	-	-	-
28	Nedumkandam	1	10	-	15	-
29	N R City	1	10	-	-	-
30	Pampadumpara	1	-	17	-	-
31	Parathode	2	-	25	20	50
32	Pasupara	1	-	-	15	-
33	Poopara	1	-	-	15	-
34	Pushpakandam	1	-	-	-	8
35	Pottankadu	2	-	25	-	25
36	Pulianmala	1	-	-	50	-
37	Puttady	1	-	-	40	50
38	Rajakkad	5	50	35	-	12
39	Rajakumari	1	-	-	-	-
40	Ramakkalmedu	1	-	30	-	-
41	Santhanpara	1	-	-	-	5
42	Suryanelly	2	47	-	-	-
43	Thookupalam	1	-	-	-	1
44	Udumbanchola	1	20	-	-	-
45	Vazhavara	1	50	-	-	-
46	Vilakkanur	1	-	-	-	25
47	Vallakadavu	3	36	-	-	20

Fig. 1. Plant samples showing symptoms of root rot, panicle wilt, pseudostem rot and rhizome rot

The pathogen affected roots, panicles, pseudostem and rhizomes of small cardamom plants causing root rot and foliar yellowing, panicle wilt, pseudostem rot and rhizome rot (Fig. 1). The incidence of panicle wilt was observed to be severe in plantations of 4-6 years age during October to March period of 2010-11 at Kallupalam, Pulyanmala and Putattdy. There was no foliar yellowing and root tip rot or pseudostem rot incidence in these plants at Kallupalam. The symptoms of panicle wilt were so characteristic that drying starts from the panicle tip and proceeds towards the base.

Isolation of pathogen, identification and pathogenicity

The pathogens were isolated from diseased samples such as root tip, pseudostem, panicle and rhizome collected from various locations and purified by adopting standard procedures. The various diseases observed *viz*., root tip rot, pseudostem rot, panicle wilt and rhizome rot were found to be caused by *F. oxysporum*. *Fusarium* specific medium (FSM) was used for isolation of pathogens. The pure cultures of the pathogens were made from root tip rot, panicle wilt, pseudostem rot and rhizome rot infections for further studies (ITCC No 6245 and 6246). The microscopic observations revealed that pathogen produced both microconidia and macroconidia in abundance (Booth, 1971). Pathogenicity and cross infectivity of the pathogens were also proved and *F. oxysporum* was re-isolated from the diseased plant parts such as roots, panicles, rhizomes and pseudostem of small cardamom.

Table 3. Comparative incidence of *Fusarium* infections in small cardamom in the field

Treatments	Mean disease incidence (%)				
	Leaf yellowing	Root rot	Pseudostem rot	Clump rot	Panicle wilt
T_1	5.28	11.31	1.23	0.20	9.29
T_2 – Th + Pf + EPN	5.66	11.43	2.53	0.08	9.05
T_3 – Th + Pf + *Paecilomyces*	6.97	12.06	3.31	0.21	9.47
T_4 – Th+Pf +EPN+*Paecilomyces*	5.80	11.36	3.23	0.39	9.93
T_5 – EEM	8.06	16.60	2.87	0.60	13.21
T_6 – Carbendazim + Mancozeb	5.51	11.53	3.38	0.10	11.79
T_7 – EPN	21.32	32.79	9.66	1.64	20.68
T_8 - *Paecilomyces*	28.17	27.39	7.64	1.42	2074
T_9 - Control	28.17	36.51	13.49	2.43	26.51
CD (5%)	5.09	5.60	2.70	NS	3.88

Th- *Trichoderma harzianum,* Pf- *Pseudomonas fluorescens,* EPN- Entomo pathogenic nematode, EEM- Effective micro organism

Table 4. Population of bioagents and ***F. oxysporum*** **in the treated field plots after third round of treatments**

Treatments	*T. harzianum* Mean 10^4 cfu gm^{-1}	*P. fluorescens* Mean 10^4 cfu gm^{-1}	*F. oxysporum* Mean 10 cfu gm^{-1}
T1 – Th + Pf	2.0	2.5	2.0
T2 – Th + Pf + EPN	2.0	1.5	3.3
T3 – Th + Pf + *Paecilomyces*	2.0	1.3	2.3
T4 – Th + Pf + EPN + *Paecilomyces*	2.8	1.3	1.8
T5 – EEM	0.0	0.0	4.0
T6 – Carbendazim + Mancozeb.	0.0	0.0	2.5
T7 – EPN	0.0	0.0	4.5
T8 – *Paecilomyces*	0.0	0.0	4.3
T9 – Control	0.0	0.0	7.9

The four major *Fusarium* diseases of small cardamom studied include root tip rot and foliar yellowing, pseudostem rot, panicle wilt and rhizome rot. These infections were found to be caused by *F. oxysporum* and were severe during post monsoon season in the field. Incidence of *Fusarium* diseases was also reported earlier in small cardamom (Wilson *et al.*, 1979, Siddaramaiah, 1988, Dhanpal and Thomas, 1988 and Vijayan *et al.*, 2008) but four distinct types of infections caused by *F. oxysporum* are reported from the present study.

Disease management in the field

The results of pooled data for 2009-2011 are presented in Table 3. The study revealed that there was incidence of root tip rot, foliar yellowing, pseudostem rot, panicle wilt and rhizome rot symptoms in all the treatments. The highest incidence of *Fusarium* diseases was recorded in untreated control for all the four types of infections. The results showed that basal application of *Trichoderma harzianum* and spraying and drenching with *Pseudomonas fluorescence* was significant for the control of root tip rot, leaf yellowing, pseudostem rot and panicle wilt. Further, the population levels of *T. harzianum* and *P. fluorescence* were significantly higher in the treated plots (Table 4). These bio-control agents have been shown to be effective in root rot diseases in several crop plants (Kudryavasteva, 1980; Vyas, 1994; Vijayan *et al.*, 2008). The present study shown that basal application of *T. harzianum* and spraying and drenching with *P. fluorescence* was significant for the control of root tip rot and leaf yellowing; pseudostem rot and panicle wilt in the treated plots giving a clear indication of scope for developing effective eco-friendly and non chemical control of the disease.

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